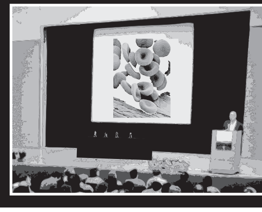
Conference Scene

2009 IEEE NSS/MIC in the USA



56th Nuclear Science Symposium and Medical Imaging Conference organized by the IEEE Nuclear and Plasma Sciences Society
Orlando, FL, USA, 25–31 October 2009

Over the past 50 years, the IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC) has become a premier annual meeting in the area of radiation detection instrumentation and associated applications ranging from fields of high-energy physics to medical imaging. In 2009, the conference drew more than 1800 scientists and trainees from 48 countries. This article focuses on the Medical Imaging Conference (MIC) portion of the meeting, where Program Chair RD Badawi and the conference committee had prepared an excellent scientific and educational program.

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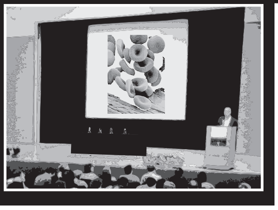
Radiation imaging systems have already become an essential component of both clinical and preclinical sciences. Applications of such systems include, but are not limited to, the study of molecular level processes, screening and staging of disease, and monitoring response to existing and novel treatment regimens. As the field of medical imaging evolves, there is an urgent need for the development of high performance fast systems producing detailed quantitative images that are easy to visualize and interpret by clinicians/scientists. In the process of developing these future generation imaging systems, several interdependent tasks must be performed. First, radiation detectors must be simulated, designed and fabricated, and their geometrical configuration should be optimized so as to yield the desired performance. Second, efficient but flexible electronic systems must be designed to support the detection system. Third, fast computer algorithms must be developed, initially to accurately model the physical process of creation, propagation and detection of radiation photons and then to invert that process so that quantitatively accurate images can be reconstructed. Fourth, either hardware- or software-based correction methods must be implemented to compensate for subject motion in scanners. Fifth, image processing methods must be developed that allow for better visualization, quantification and interpretation of measured data. Through scientific sessions at the 2009 MIC, all these aspects were addressed and the latest developments in these areas were presented. A few of these aspects were also addressed through educational sessions (eight special workshops and seven short courses). A total of 514 scientific submissions were accepted: 84 as oral presentations, 47 as 'premium' posters, and the rest as poster presentations. In the subsequent sections, the emerging themes from the conference are discussed.

PET/MRI & SPECT/MRI

Over the past decade, there has been a rapid increase in the number of researchers developing PET/MRI and SPECT/MRI scanners. Two approaches have been pursued: simultaneous acquisition of both PET or SPECT and MRI, and sequential acquisition of the two types of images. In the former approach, radiation detector inserts have been developed that fit into the bore of a conventional MRI scanner. For example, Meier *et al.* (Gamma Medica) described the performance of a small animal SPECT insert in a preclinical MRI system, while Shultz *et al.* (Philips) presented updates on a small animal PET device being built to fit into a human MRI scanner. On the other hand, Vandenberghe *et al.* (MEDISIP) presented simulation results of a sequential PET/MRI scanner highlighting the design challenges in the task.

Correction of attenuation to PET photons by biological tissue is necessary for accurate quantification in PET. Direct derivation of the PET attenuation map from MRI images, however, is nontrivial. Catana *et al.* (Massachusetts General Hospital, MA, USA) discussed current challenges for attenuation correction (AC) in an MRI-compatible human



brain PET scanner and provided potential solutions. Chaudhari *et al.* (UC Davis, CA, USA) presented a method for AC for preclinical PET/MRI systems where the PET attenuation map would be derived by nonrigid image registration to a digital mouse atlas. The AC method already implemented on a commercial whole-body clinical PET/MRI scanner was evaluated by Zhang *et al.* (Philips) and potential pitfalls were highlighted.

Time-of-flight PET

For PET, a pair of annihilation photons emitted by the decay of a radionuclide is detected and registered by opposing detectors. By using extremely fast detectors, the difference in arrival times of the two photons (or time-of-flight [TOF]) can be measured and be used to more accurately predict the point of origination of the photons. TOF-PET clinical scanners have now become available commercially, although detailed characterization of image quality improvement from these devices over non-TOF scanners is still a subject of active investigation. Turkington *et al.* (Duke University, NC, USA) showed phantom and patient images highlighting how TOF information can indeed help reduce artifacts arising due to an inaccurate attenuation map in PET. Measured data with TOF devices are an order of magnitude larger than that from non-TOF scanners. Thus, computer algorithms for image reconstruction that are able to utilize maximum information in the data with minimal increase in computational cost are highly desirable. Ahn *et al.* (University of Southern California, CA, USA) described a reconstruction method based on data re-binning that allowed them to fully capitalize on the timing information gained for the annihilation photons while still keeping the computational time equivalent to that for conventional 3D reconstruction methods. Initial evaluation studies for a big bore (85 cm patient port against 70 cm) TOF-PET scanner were also shown by Scheuermann *et al.* (University of Pennsylvania, PA, USA).

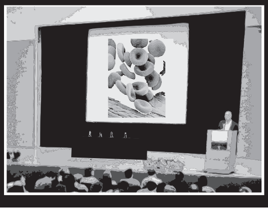
Electronics of the future

High performance readout electronics are essential for obtaining optimal performance from radiation imaging devices. Such electronics need to be scalable from a prototype design to the entire system and also be flexible so that it can be used for a wide variety of detector designs and scanner geometries. Currently, high performance electronics are available commercially but it is not affordable for small research laboratories and is not flexible since it is designed for one specific scanner and is proprietary. Moses *et al.* (Lawrence Berkeley Laboratory, CA, USA) presented a design for readout electronics, called OpenPET [1], which would not only be simple and customizable but also, open source (that is, users will have full access to all technical data, schematics and documentation needed to fabricate the circuit boards). Contribution to this project from the research community at large was requested in order to potentially provide easy solutions to common problems encountered in the field.

Photodetector & scintillator technologies

In hybrid PET/MRI systems, avalanche photodiodes (APDs) whose operation is minimally affected by magnetic fields have replaced conventional photomultiplier tubes (PMTs). APDs, however, have a substantially lower signal-to-noise ratio and worse timing properties compared with PMTs. The recently developed silicon photomultiplier (SiPM) technology shows potential to bridge the gap between PMTs and APDs. At the meeting, Siefert *et al.* (Delft University of Technology, The Netherlands) presented timing characterization results for SiPMs for application in TOF-PET. New developments in the readout electronics for SiPMs were presented by Marcatili *et al.* (University of Pisa, Italy) for a PET scanner prototype the authors have built. Characteristics of a SiPM-based block detector were presented by Song *et al.* (Washington University, MO, USA) and were extrapolated to the complete scanner. A short course on the physics and design of detectors for SPECT and PET (instructors – L Furenlid and H Barrett, both University of Arizona, AZ, USA, and T Lewellen, University of Washington, MO, USA) provided a comprehensive overview of new technologies employed in the field.

For x-ray CT scanners, several new detector designs were proposed through the presentations at the meeting. Noticeably, Nagarkar *et al.* (RMD) reported on the



fabrication procedure and characteristics of a novel scintillator based on ZnTe:O that is well-suited for CCD sensors, while Barber *et al.* (DxRay) described a fast photon-counting single crystal Cd:Te x-ray detector coupled to an application-specific integrated circuit. The latter has potential application in clinical dual-energy x-ray absorptiometry.

Image reconstruction using graphics processing units

3D image reconstruction schemes incorporating accurate models of photon generation, propagation and detection are computationally very expensive. Additionally, with modern scanners that have a large number of lines of response and the capability of TOF (PET) or dual-energy imaging (CT), conventional implementations of reconstruction schemes – even on large computer clusters – are inefficient. Graphics processing units, efficient for manipulation of computer graphics, provide an attractive alternative for image reconstruction. At the meeting, more than 30 presentations focused on the use of graphics processing units in performing various image reconstruction tasks for PET, SPECT and CT. A short course was also held on this topic.

Small animal imagers

More than 20 new designs for small-animal scanners were presented at this meeting. Particularly noteworthy were presentations from two research groups. Mitchell *et al.* (UC Davis) showed imaging results from injecting a mouse with a fluorine-18-based radiotracer and directly detecting the resulting Cerenkov radiation using a CCD camera. According to the authors, this technique would find potential application in laboratories where only optical imaging instruments are available and access to PET or SPECT scanners is difficult. Performance characteristics of a novel dual-head mouse imager called PETBox was presented by Zhang *et al.* (University of California, Los Angeles, CA, USA). This low-cost and easy-to-use device could be a promising tool for performing high-throughput small-animal biodistribution studies.

Plenary talks, awards & 2010 NSS/MIC

Three plenary talks were organized; one on the longevity of the Anger Camera (Gerd Muehllehner), the second on the history of the widely used LSO:Ce scintillator (Charles Melcher, University of Tennessee, TN, USA) and the third on imaging of stem cell transplantations (Kitch Wilson, Stanford University, CA, USA).

Benjamin Tsui (Johns Hopkins University, MD, USA) was awarded the 2009 Edward J Hoffman Medical Imaging Scientist Award, Jinyi Qi (UC Davis) the IEEE Early Achievement Award, while Katia Parodi (University of Heidelberg, Germany) received the 2009 Bruce Hasegawa Young Investigator Medical Imaging Science Award. A student paper competition was organized as a part of the MIC and had more than 100 entries. Papers by Sara St James (UC Davis), Peter Olcott (Stanford University) and Andrea Ferrero (UC Davis) won first, second and third place, respectively, in this competition.

The 2010 IEEE NSS/MIC will be held from 30 October–6 November in Knoxville, TN, USA. This promises to be another unique opportunity to share exciting advances in the field of radiation detection/imaging systems.

Financial & competing interests disclosure

The author has no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

Website

1 General Purpose Readout Electronics for Radionuclide Imaging. openPET http://openpet.lbl.gov